Engagement Opportunities in NASA STEM 2023 (EONS-2023)
NASA Research Announcement (NRA)
MUREP Space Technology Artemis Research (M-STAR)
Number: NNH23ZHA001N-MSTAR

Title: Muscular Atrophy Effects of Long Duration Human Exploration Mission on Vocal Fold Adduction for Airway Protection

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Summary: Atrophy of "anti-gravity" muscles (muscles responsible for postural stability) is common during space travel. Exercise regimens for microgravity-induced muscular atrophy have typically focused on the large muscles of stability such as the quadriceps formis, the soleus muscles, and the muscles of the back. However, the thyroarytenoid muscles which form the bulk of the vocal folds have not been evaluated. While the vocal folds are typically thought of as the muscles we use for voice, they also perform life sustaining functions, including airway protection during swallowing, preventing aspiration, and providing postural stability for movements requiring force. Compensatory techniques allow for healthy speech in mild atrophy, likely resulting in normative speech in space; however, these mechanisms cannot compensate for the inability to adduct the vocal fold.

Both computational and experimental investigations will be performed to study muscular atrophy effects of long duration human exploration mission on vocal fold adduction for airway protection. Initially, in vivo experiments will be performed with normal and induced atrophic vocal folds in rabbits. MRI scans and digital kymography will provide baseline data for computational model reconstruction and evaluation. Fluid structure interaction modeling and experiments will be performed to analyze the muscular atrophy effect on vocal fold adduction by comparing normal and atrophic conditions. In the second task, a poro-elastic model will be developed to mimic the tissue behavior in response to surface electrical stimulation – a plausible treatment for atrophic vocal fold induced by zero-gravity. In the final task, in vivo experiments will be performed to validate findings of the poro-elastic model on surface electrical stimulation effects on vocal fold atrophy. This research will enrich fundamental understanding of muscular atrophy effects on vocal fold adduction induced by zero-gravity and contribute to airway protection for astronauts in long duration human exploration mission.

This proposed work aligns well with NASA's two priority Strategic Objectives: 2.3: Develop capabilities and perform research to safeguard explorers; 4.1: Attract and develop a talented and diverse workforce. The proposed work also aligns with all the goals and objectives of M-STAR, such as contributing the novel research in STMD, promoting the diverse workforce, preparing the institution for continuous funding applications. This award will contribute significantly to the

development of institutional capabilities and the advancement of research directly related to STMD at MSU.

This award will provide research opportunities in aerospace topics related to NASA to undergraduate students, graduate students, postdoctoral fellows, and faculty at MSU. Multiple students will be supported by this award to pursue their degrees, while summer internships will also be provided to undergraduates. Through collaboration with Pitt, researchers from MSU can access preclinical data and expertise in voice biology, which are not available at MSU. This award will also contribute to the new curriculum development in the aerospace area for both Master's and Ph. D. degree programs in the Mechatronics Engineering Department at MSU.